Title
Benchmarking Anticipated Wind Project Lifetimes: Results from a Survey of U.S. Wind Industry Professionals

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Benchmarking Anticipated Wind Project Lifetimes:

Results from a Survey of U.S. Wind Industry Professionals

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This paper draws on a survey of wind industry professionals to clarify trends in the expected useful life of land-based wind power plants in the United States. The expected useful life of a project affects expectations about its profitability, the timing of possible decommissioning or repowering, and its levelized costs.

We find that most wind project developers, sponsors and long-term owners have increased project-life assumptions over time, from a typical term of ~20 years in the early 2000s to ~25 years by the mid-2010s and ~30 years more recently. Current assumptions range from 25 to 40 years, with an average of 29.6 years.

The estimated average levelized cost of energy (LCOE) for new wind projects built in 2018 is $40.4/MWh (real 2018$), assuming a 20-year project life. With a 25-year useful life and no change in assumed operations and maintenance (O&M) expenditures or wind plant performance over time, LCOE declines by 10%, to $36.2/MWh, because capital costs are recovered over five additional years of production. At the now-common 30-year assumed life, levelized costs decrease another 7%, to $33.5/MWh (under the same unaltered assumptions about O&M and performance). Even longer assumed lifetimes lead to further (but diminishing) LCOE reductions—e.g., to $31.7/MWh and $30.3/MWh for 35- and 40-year lives, respectively.

The data and trends presented here may inform assumptions used by electric system planners, modelers and analysts. The results may also provide useful benchmarks to the wind industry, helping developers and assets owners to compare their expectations with those of their peers.

Methods

The findings in this paper largely draw from a brief survey of U.S. wind project developers, sponsors, financiers, and consultants. We distributed the survey to staff at 23 different organizations in August 2019. Responses were received from 21 staff at 18 of these organizations, for an overall (organizational) response rate of 78%. Additionally, we conducted a review of the annual financial reports from some of the large, publicly traded wind project developers and owners, yielding three additional sets of project-life assumptions.[1] Ultimately, we assembled 20 different time-series estimates of useful project life.[2]

Our interest was in better understanding how expectations for useful life have changed over time, as the industry has grown and matured. We focus on 'useful' life, defined here to mean the period of time in which the expected costs and revenues of a project are assessed to determine its economic viability. Typically, an asset with a useful life of, for example, 30 years is expected to earn ongoing operating profits during those 30 years (ongoing revenue > ongoing costs). At the end of year 30, however, either decommissioning or full

[1] In some cases, project-life assumptions that derive from financial reports reflect depreciation- or accounting-based lives, which may in theory differ from useful-life assumptions used by developers and sponsors. However, a review of our results indicates no such bias in the estimates reported later in this paper, as the distribution of responses is similar in both sources of data.

[2] These estimates, and other survey responses that we report later, come from staff and annual reports from: NextEra, RES, EDPR, Apex, Enel, Avangrid, EDF, Pattern, Scout, Leeward, MAP, Vestas, AEP, Berkshire Hathaway, JP Morgan, Wells Fargo, Clear Wind, Wood Mackenzie, and DNV GL.

project repowering would be expected. A longer assumed project life may enhance the expected long-term profitability of a project, assuming any resulting increase in O&M is kept within reasonable bounds. Moreover, longer depreciation terms reduce annual book depreciation from an accounting perspective, thereby boosting net income in the near term. From a planning and modeling perspective, meanwhile, longer lifetimes may enable lower LCOE by recovering up-front capital costs (and, potentially, any component replacement or refurbishment costs) over additional years of electricity production.

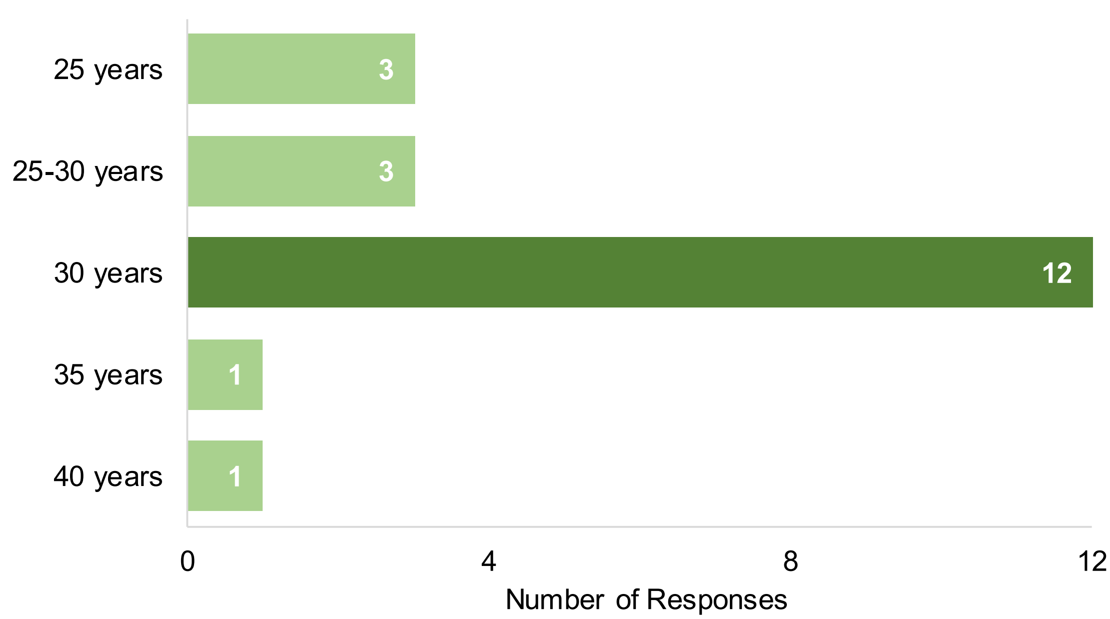
We focused on expectations from project developers, sponsors, and long-term owners because these are the entities most likely to be thinking about the full lifecycle of a project. However, we recognize that each participant in a wind project may have different perspective on what 'project life' means, or how it matters. A lender, for example, will primarily care about the revenue and costs of a project over the term of the loan: often 15 years or less. Tax equity providers may focus on the first 10-12 years, during which their returns are earned. Engineers might think of the certified life of the turbines (20 years historically, but now 25, 30 or even 40 years in some cases), or the engineering design life of the project. Providers of operations and maintenance services might consider the lifetime of any O&M contracts.

We specifically sought insights into assumptions that project developers, sponsors and long-term owners most-commonly use for project life, when considering the lifetime profitability of a project, pitching projects to financiers, and establishing power purchase agreements (PPAs) during the development and financing process. We also included major consultancies in our sample, including those that provide due diligence services to the wind industry. We asked about current assumptions, and how those assumptions have changed over time. Some respondents offered additional insights, which we share as appropriate.

Estimated Project Lifetimes

Project developers, sponsors, and long-term owners now most-commonly assume 30-year useful project lives, as depicted in Figure 1.

Figure 1. Current Useful-Life Expectations for Wind Plants



Specifically, twelve sources cited 30 years, three cited 25-30 years (averaged to 27.5 years in Figure 2), three cited 25 years, one cited 35 years, and another cited 40 years.[3] None of the respondents uses a 20-year project life assumption; several respondents also noted that they are not aware of others in the wind industry still using a 20-year assumption.

Expectations for the useful life of wind projects vary by respondent, but have consistently increased over time—from a typical value of ~20 years in the early 2000s and prior, to ~25 years by the mid-2010s, and then to ~30 years most recently (Figure 2, Table 1). The average among respondents for 2019 is 29.6 years.

Figure 2. Useful-Life Expectations for Wind, over Time

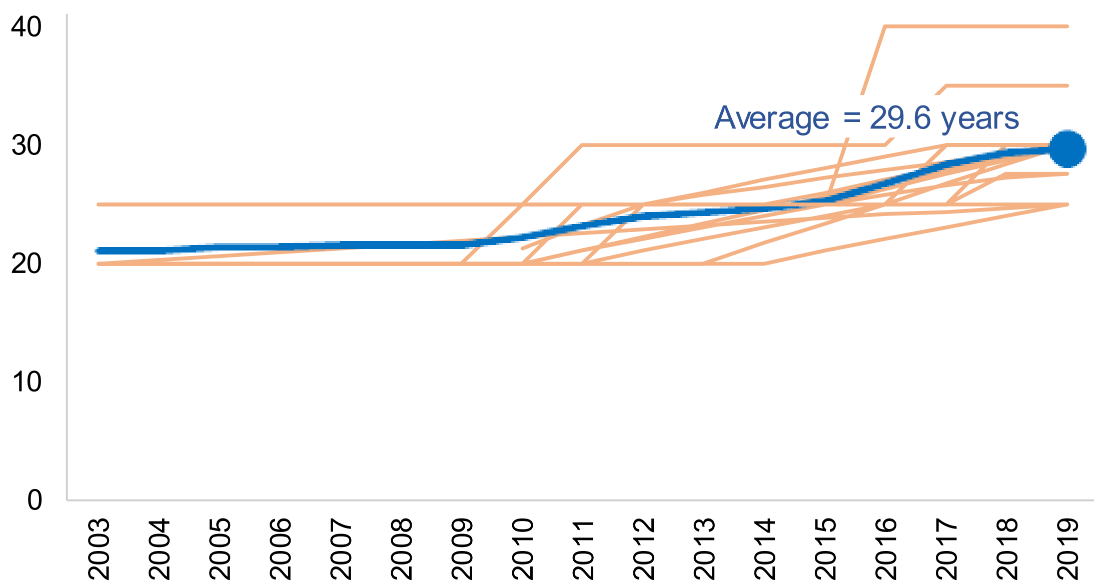


Table 1. Summary of Respondent Estimates of Useful-Life Expectations for Wind Projects

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Source 1	25	25	25	25	25	25	25	25	30	30	30	30	30	30	35	35	35
Source 2										25	26	27	28	29	30	30	30
Source 3	25	25	25	25	25	25	25	25	25	25	25	25	26	27	28	29	30
Source 4	20	20	20	20	20	20	20	20	25	25	25	25	25	25	30	30	30
Source 5								21	23	25	26	26	27	28	29	29	30
Source 6	20	20	20	20	20	20	20	20	20	25	25	25	25	25	25	30	30
Source 7													25	40	40	40	40
Source 8	20	20	20	20	20	20	20	25	25	25	25	25	25	25	30	30	30
Source 9	20	20	20	20	20	20	20	20	21	22	23	24	26	27	28	29	30
Source 10																	30
Source 11									25	25	25	25	25	25	30	30	30
Source 12	20	20	20	20	20	20	20	20	20	20	20	20	21	22	23	24	25
Source 13								25	25	25	25	25	25	26	28	29	30
Source 14	20	20	20	20	20	20	20	20	20	20	20	22	23	25	27	28	30
Source 15			25	25	25	25	25	25	25	25	25	25	25	25	25	27.5	27.5
Source 16																	30
Source 17	20	20	20	20	20	20	20	20	21	22	23	24	25	26	27	27	27.5
Source 18																	27.5
Source 19									20	21	22	23	24	25	25	25	25
Source 20	20	20	21	21	21	22	22	22	23	23	23	23	24	24	24	25	25
AVERAGE	**21.0**	**21.0**	**21.4**	**21.4**	**21.5**	**21.5**	**21.5**	**22.2**	**23.2**	**23.9**	**24.3**	**24.7**	**25.2**	**26.7**	**28.4**	**29.3**	**29.6**
# Responses	*10*	*10*	*11*	*11*	*11*	*11*	*11*	*13*	*15*	*16*	*16*	*16*	*17*	*17*	*17*	*17*	*20*

[3] The firm applying a 40-year assumption notes, however, that this assumption is capped at the term of each project's lease, resulting in a fleet-wide average useful life of 31 years. Moreover, the firm is not altogether clear as to whether the 40-year life applies to entire wind projects, or instead to just certain components of those projects and turbines.

Drivers and Influences

In addition to these numerical estimates, many respondents offered insight into how they or the industry treat project life. Though we do not seek to synthesize generalizable findings from these insights, they do enhance understanding of industry thinking, and so are summarized below where relevant:

- Some respondents noted that turbine design certifications are often 20 years, though some manufacturers are moving towards or already provide 25-, 30-, or even 40-year certifications depending on the turbine and wind regime. Moreover, O&M servicing agreements sometimes (albeit rarely) extend to 25- or even 30-years. Such service agreements may not cover component replacement, and so project owners may still face O&M risk. Nonetheless, in general, these points suggest that the major manufacturers are increasingly comfortable with 30-year lifespans.
- One respondent pointed out, however, that project owners need not equate turbine certification lives with the useful, economic, or depreciable life of a wind power asset. Owners will conduct project-specific engineering and economic analysis to inform useful-life assumptions, considering local wind conditions, expected project revenue, and O&M and refurbishment expectations. As such, regardless of the details on turbine certification and servicing contracts, 30-year lifetimes are now the most common, though a number of developers and sponsors continue to use 25 years or a range of 25-30 years.
- Multiple developers revealed that key factors in increased project lives include technology maturity and robustness, as well as improved understanding of performance, wear-and-tear, and O&M practices. Projects from the 1980s and 1990s continue to operate today in some cases, turbines in the 1+ MW class have growing operating history, and engineering and operational skill and turbine sophistication has dramatically increased. As older projects have reached their design lifetimes, the industry has found ways to extend those lifetimes. Turbine control regimes that clip production to manage fatigue loads and ensure that turbines stay within their design envelope have become increasingly common. One major independent engineering firm agrees that, if taken care of, a facility should last 25-30 years or longer with proper maintenance protocols and, for some components such as gearboxes, plant refurbishment. The recent emergence of 'partial' repowering whereby certain turbine component are replaced and/or upgraded has bolstered confidence in longer useful lives (at least for those turbines that are being refurbished), as have enhanced O&M options and lower overall O&M costs.
- The O&M implications of extended useful lives are uncertain. Some turbine components can easily last 30+ years whereas others, such as gearboxes, would likely require refurbishment or replacement. While acknowledging uncertainty in future O&M costs, a limited number of respondents indicated that they do not anticipate a fundamental step-change in O&M expenditures to achieve 25-year lives. Others indicated that heightened O&M costs and component refurbishment and replacement go hand-in-hand with extended project life, as might increased performance degradation, especially to achieve 30-year life spans—also noting that these effects are factored-in when assessing overall plant profitability and determining useful life. Ultimately, the actual useful life of wind assets will depend critically on how components wear over time, which will affect O&M expenditures.
- Another factor in extended project lives is the desire, and perhaps even need, to capture project value/economics beyond the initial 10-20 year life that is usually covered by the first power purchase agreement (PPA). The extent of this post-PPA (and post-PTC) 'merchant' value is often an item of wide disagreement within the industry, and depends on the trajectory of both power prices and O&M costs. Two respondents noted that today's low wholesale power prices were generally not anticipated a decade ago, challenging post-PPA project economics for older projects. Nonetheless, especially as PPA

terms have tended to shorten over time and competition for those PPAs has strengthened—resulting in lower PPA-derived revenue—an increasing number of projects need to demonstrate some post-PPA value in order for the project to pencil out from an overall return-on-investment perspective. These trends have pushed the industry to more fully investigate longer useful lives. Ultimately, though, whether this post-PPA value materializes will depend on O&M requirements as projects age and, critically, on future wholesale power price developments. These two factors, post-PPA revenue and O&M costs, are generally viewed as the two most uncertain aspects of project life estimates.

- Developers indicated that different owners treat and model project life somewhat differently. For example, one respondent indicated that its firm has historically modeled 25-year project lives as 20 years of revenue plus a terminal value (which is equated to 5 years of net revenue); a separate respondent indicated that this approach was very common earlier in the 2000s. Another respondent mentioned that its company typically assumes 25 years, but with the final 5 years subject to production degradation. An independent engineer revealed that, over the last several years, it has noticed that longer lifetimes have been supported by increasingly sophisticated engineering and economic analysis, whereas previously that analytical support was often somewhat lacking.
- Regional variation in project life assumptions may also exist. Wind plants located in areas with liquid wholesale markets (ERCOT, SPP, MISO, etc.) that enable projects to readily go merchant once the initial PPA expires are more likely to use an assumed life of 30 years. Projects located in illiquid markets (WECC, SERC, FRCC) and selling to an electric utility may more-regularly assume a project life equivalent to the term of the PPA—typically less than 30 years.
- One sponsor remarked that it reviews the estimated useful lives of its assets on an ongoing basis and that, in 2016, this review indicated that many of its wind projects were expected to last longer than previously estimated for depreciation purposes. As a result, the useful lives of certain wind assets[4] were increased from 25 years to 40 years, capped at the land lease term if lower, to better reflect the periods during which these assets are expected to remain in service. The weighted-average useful life of its wind projects was consequently 31 years, and the company is assessing lease extensions to potentially further increase the average useful life of its collective wind assets.
- Another developer and owner reported that it opted to conduct a rigorous independent assessment of its fleet in the early 2010s, taking into account local wind conditions and assessing lifetime both from a structural and economical perspective. From a structural point of view, it analyzed structural components that could not be reasonably replaced, conducting extreme load and fatigue analyses on 37 wind projects, representative of the conditions of all 161 wind projects in its fleet at the time. This owner concluded that, for all wind projects analyzed, failure rates for these components would be lower than 0.5% during a period of 25 years. In parallel, this owner conducted an economic analysis to ensure that operating each of the projects was profitable during these 25 years. Estimated costs were compared with expected revenues, and in all cases, expected revenues remained above expected operational costs during the 25-year lifetime of the assets. Finally, a thorough analysis was conducted to make sure no project had any contractual, land lease, environmental or legal restriction that would prohibit extending operations to 25 years.
- Another large asset owner noted that, in 2017, a review indicated that the actual lives of its wind plants were expected to be longer than the lifetime previously estimated for depreciation purposes. As a

[4] As indicted earlier, this firm is not altogether clear as to whether the 40-year life applies to entire wind projects, or instead to just certain components of those projects and turbines.

result, this wind plant owner changed the estimated useful lives of wind plant equipment from 30 years to 35 years, better reflecting the period during which these assets are expected to remain in service. The resultant accounting reduction in annual book depreciation had the effect of boosting near-term annual net income estimates.

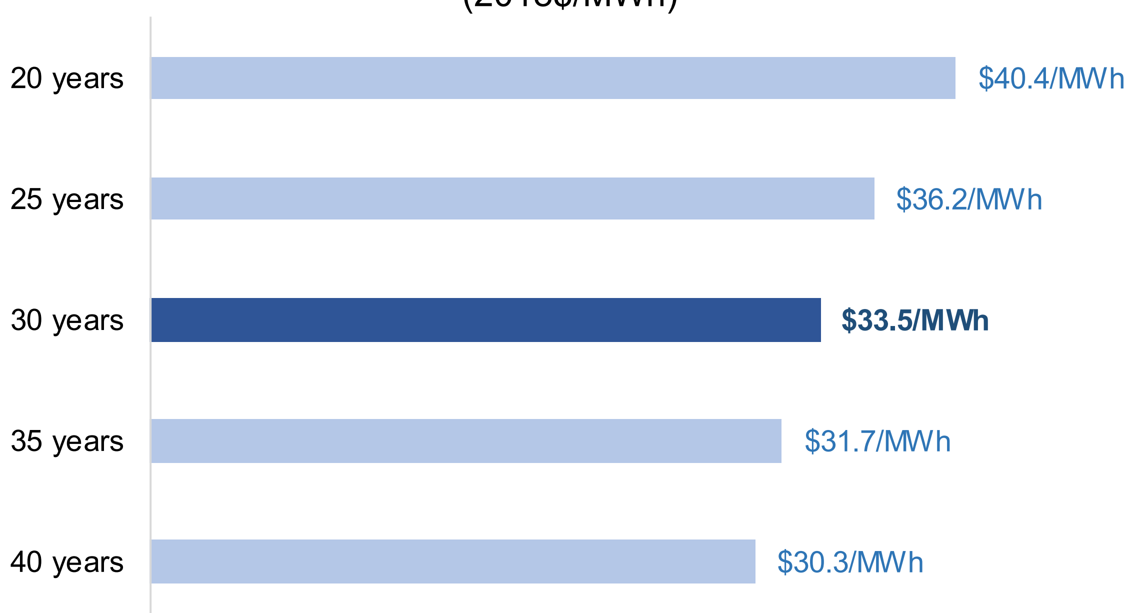
- Yet another developer indicated that it recently increased its useful life assumption from 25 years to a project-specific range of 25 to 30 years. Whether a project is assumed to have a 25-year or a 30-year useful life depends on detailed analysis that considers turbine model, foundation design, wind regime, O&M expectations, merchant-tail revenue expectations, land lease terms, and other considerations. In effect, an 'optimal' useful life is determined, through detailed analysis, for each project.
- An independent engineer cited foundation design as often the governing factor, but further noted that foundations are now commonly designed with a 30-year design life in mind. This respondent indicated that 30-year useful lives are now always employed in project-sale transactions, with shorter terms sometimes the focus in tax equity transactions and debt deals. A 25-year life used to be a stretch in the assumptions, and was not typically considered in most financings (the exception being sale-leaseback tax equity deals, but those were never prevalent). That has now changed, especially over the last few years as 30-year lifetime assumptions have become common.
- A prospective owner revealed that it recently issued an RFP for a large volume of wind that specified that it was looking to buy (at completion) 30-year design life projects with 30-year design life turbines. The solicitation further required wind developers to provide a mechanical load analysis (or equivalent) from the wind turbine manufacturer to support the design life assumption. The owner reached out to the major turbine manufacturers prior to issuing the RFP, confirming that each of those manufacturers could meet the requirement depending on the wind regime, albeit with high O&M costs to be expected in the later years.
- One respondent cited an accounting perspective as a primary driver for recent increases in assumed lifetimes: longer depreciation terms reduce annual book depreciation from an accounting perspective, thereby boosting near-term net income (all else being equal). This same respondent observed that increases in assumed project lives correlated (in time) with a move in the industry to capitalize (and therefore depreciate, not expense) major operating expenses such as gearbox replacements.
- Tax equity and lenders are often less-impacted by project term. Lenders are generally focused on ensuring that loans are repaid during the term of the PPA—before the project has merchant exposure. Tax-equity providers are similarly not always overly concerned with project life, but rather with the first 10+ years or so of operation, and making sure that energy generation matches expectations such that federal tax incentives are fully captured. This is not to say that longer project lives are ignored by these project participants, but only that useful life—whether 25- or 30-years—is less often a governing factor in investment decisions.
- One financier declared that it tends to have a somewhat more conservative view—using 25 years as the technical and economic lifetime, albeit acknowledging that many others have gained comfort with 30 years. This respondent also indicated that the actual incremental value of years 25 to 30 is generally quite low in present value terms, especially if there is need for increased O&M or refurbishment.
- Finally, an independent engineer suggested that, in the future, further extensions to project life might be enabled by even-more-sophisticated control strategies that seek to maximize overall lifetime plant profitability, by trading off immediate power production (especially when wholesale power prices are

very low) against plant-lifetime 'consumption' and O&M costs. While these strategies are not yet employed broadly, the computational tools and expertise exist to potentially self-curtail during periods of high fatigue and low wholesale prices, thereby reducing future O&M costs and extending project life. Moreover, in the wake of a phased-out PTC, such strategies could become more common as the current PTC-induced emphasis on near-term production begins to shift in favor of longer-term considerations.

Impacts on Levelized Cost of Energy

The estimated average levelized cost of energy (LCOE) for new wind projects built in 2018 is $40.4/MWh (real 2018$), assuming a 20-year project life and excluding the impacts of the federal production tax credit (Figure 3).[5] With a 25-year useful life and no change in assumed operations and maintenance (O&M) expenditures or project performance over time, LCOE declines by 10%, to $36.2/MWh because capital costs are recovered over five additional years of production. At the now-common 30-year assumed life, levelized costs decrease another 7%, to $33.5/MWh (again, all else equal). Even longer assumed lifetimes lead to further, but diminishing (due to discounting), LCOE reductions—to $31.7/MWh and $30.3/MWh for 35- and 40-year lives, respectively. These estimates assume that O&M costs simply scale with inflation regardless of useful life and that performance degradation as projects age is not present. Consequently, the analysis overstates the benefits of extended project lifetimes on LCOE, though is still suggestive of a potentially significant positive influence, at least among the nearer-term extensions from 20 to 25 to 30 years (whereas discounting erodes the benefits of longer-term extensions from 30 to 35 to 40 years).

Figure 3. Levelized Cost of Wind in 2018, by Project Life (2018$/MWh)



Project lifetime is not as impactful as installed costs and annual electricity production for determining the overall levelized cost of wind energy. Nonetheless, if O&M costs can be contained, project life is one of several levers (that also include financing and O&M) that helps reduce the levelized cost of wind energy.

[5] These LCOE estimates apply empirical data and assumptions for installed costs, O&M costs, capacity factors, and financing from Wiser, R. and M. Bolinger. 2019. *2018 Wind Technologies Market Report*. Washington, DC: U.S. Department of Energy.

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